SEA TURTLE TAGGING AND HEALTH ASSESSMENT STUDY IN MARYLAND'S CHESAPEAKE BAY

AND

SUMMARY OF SEA TURTLE STRANDINGS IN MARYLAND, 1991 TO 2003

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OBJECTIVES (from statement of work): The contractor shall fulfill the following objectives:

1) Develop and maintain cooperative agreements with pound net fishermen in Maryland to foster the exchange of information between watermen and researchers;
2) Determine distribution, migration patterns, and baseline health of sea turtles in Maryland's Chesapeake Bay;
3) Determine regional population structure and geographical origin of individual sea turtles found in the Chesapeake Bay;
4) Compare tagging and blood work results with data collected from the Lower Chesapeake Bay and other studies along the Atlantic Coast of the United States; and
5) Summarize and analyze historical and current sea turtle stranding information for Maryland waters.

Approach and Findings

Sea Turtle Tagging and Health Assessment Study

The Maryland Department of Natural Resources' (MDDNR) Cooperative Oxford Laboratory (COL) received funding from the NMFS on November 2, 2002 to continue the "Sea Turtle Health Assessment and Tagging Study" initiated in September 2000. Through the development of a cooperative agreement with pound net fishermen in Maryland, sea turtles incidentally captured in pound nets are weighed, measured, biopsied (for genetics), bled, tagged (flipper and PIT) and released by Fish and Wildlife Health Program (FWHP) personnel (from hereinafter "we" or "us"). This data has begun to provide vital information on habitat utilization, migratory behavior, age, growth, baseline health, sex, and geographical origin of sea turtles in the Chesapeake Bay.

Methods

When a waterman reported an incidentally captured sea turtle, we would travel to the net site with him on his next trip, which was typically the following day but could be two days later depending on the catch or weather. In each instance the turtle(s) were always present in the pound when we returned to the net site with the waterman. The turtle was brought on board the vessel as the net was being harvested. When possible, each animal was weighed, measured, photographed, bled, flipper tagged, and PIT tagged and biopsied for genetic analysis (in the case of loggerheads). No plastron measurements were taken. All of the turtles were photographed and given an identification number and the latitude and longitude of the net location was recorded. Morphometrics, including curved- and straight-line length and width measurements and weight, were collected from each turtle. Blood samples were taken from the dorsal cervical sinus and separated into the appropriate blood collection tubes, including hematocrit tubes. Next, a metal Inconel flipper tag was inserted into the second scale on the posterior edge of each front flipper. A PIT tag was inserted intra-muscularly into the triceps superficials muscle in the left front flipper. A small tissue sample was taken from the posterior edge of the rear flipper of each loggerhead and stored in a saturated salt solution with 20% DMSO for future genetic analysis. After observing the turtle for a brief period of time to ensure that it was not in any discomfort,

the turtle was released a short distance from the site of the pound net. Each pound netter received a financial compensation of $50 per turtle examined (up from $25 in previous years).

Blood samples, including two blood smear slides and two hematocrit tubes, were sent to Antech Diagnostics Laboratory in Lake Success, NY, for analysis including a reptile chemistry panel, CBC, testosterone assay for sex determination, and parasitology. The reptilian comprehensive chemistry includes the following parameters: glucose, urea nitrogen (BUN), total protein, albumin, AST, calcium, phosphorus, sodium, potassium, chloride, globulin, CPK and uric acid. The CBC measures the following: the number of white (WBC) and the fraction of the blood composed of red blood cells (hematocrit). The CBC also includes estimates of the number of different types of cells found in the blood (monocytes, eosinophils, etc.). A report containing the results of the blood work analyses for each sea turtle was faxed to the COL. All data, including blood chemistry, hematology and testosterone results, were entered into a Microsoft Access database.

The work conducted in this study is authorized by a permit issued under the authority of section 10 of the Endangered Species Act. The permit is subject to annual reauthorization based upon the receipt and approval of an annual report containing data on the preceding reporting period's research activities and those proposed for the forthcoming reporting period. An annual report summarizing the 2002 tagging season was submitted to the National Marine Fisheries Service (NMFS) on March 18, 2003. The report was reviewed and the permit reauthorization was approved, with one change in protocol. In the previous year the NMFS had requested that we place PIT tags in the triceps superficials muscle for turtles less than 40 cm or in the front left flipper over the second scale for turtles larger than 40 cm. For the 2003 season, the NMFS requested that we place PIT tags in the triceps superficials muscle for all turtles, regardless of size. This placement minimizes the chance of injury to major blood vessels and facilitates research efforts, as tags are more likely to be detected when consistently placed in the same location by field researchers.

1. Develop and maintain cooperative agreements with pound netters in MD to foster the exchange of information between watermen and researchers.

Various efforts were made to contact pound netters throughout Maryland's Chesapeake Bay to solicit help with the health assessment and tagging study. In the past two years a small number of pound netters (12) agreed to participate in the program by either allowing us to examine sea turtles incidentally captured in their pound net or by sending in turtle sighting cards to report baseline information on captures. We attended the 29th Annual East Coast Commercial Fishermen's and Aquaculture Trade Exposition in Ocean City Maryland in late January 2003. This exposition is presented by the Maryland Watermen's Association and is a three-day event. As in 2002, we set up an interactive booth at the exposition in an effort to recruit pound netters for the upcoming tagging season. Various information, including a poster outlining the turtle assessment procedure and how to get involved, turtle sighting postcards, sea turtle fact sheets, and a sign-up sheet, was displayed at the booth. We spoke with several pound netters that participated in previous years as well as some new watermen who expressed an interest in helping out with the study in 2003.

In early April we sent postcards describing the tagging study and asking for assistance to 153 pound netters registered with MDDNR to participate in the striped bass pound net fishery. While there are more pound netters registered within the state, those fishing for striped bass must enroll each year, so we were assured that these 153 individuals would be actively fishing pound nets in the Chesapeake Bay in 2003. We also called the pound netters who participated in the tagging study in the two previous years to discuss their participation in the 2003 tagging season and sent them letters and updated contact information. As a result of these efforts 3 of the 5 pound netters that participated in the 2003 tagging season were new to the study. It is important to note that one of the individuals that we worked with extensively in 2002 had an extremely poor harvest that year and therefore did not set pound nets in 2003. We sent reminder postcards and a full contact list for FWHP personnel to each participating pound netter in early June. In addition, an article describing the tagging and health assessment study and requesting assistance from pound netters was published in the June 2003 edition of the Watermen's Gazette, a local newspaper directed at Maryland watermen.

In June we submitted a letter to NMFS requesting an addendum to our current permit to add several pound netters to the permit as Co-Investigators. The addendum would authorize these individuals to remove sea turtles from the pound nets and transport them to us dockside for examination. Over the past two years we have worked with a small number of pound netters but have found that many others are hesitant to participate in the study for several reasons. Some will not leave sea turtles in their nets overnight because they feel that the turtles scare the fish and may cause damage to the nets. Others find it extremely difficult and troublesome to fish a net that contains a large sea turtle with the intent of leaving it in the net until the following day, and therefore, release the animal as soon as the net is drawn. In addition, many pound netters do not fish their nets on consecutive days, and therefore, do not want to leave a turtle in a net over multiple days. In speaking with numerous pound netters from around the Chesapeake Bay, several indicated to us that they would be more willing to participate in the study if they were able to transport the turtles to the dock for examination. This minimizes the inconvenience to them and would greatly benefit our tagging program by allowing us to examine a greater number of sea turtles each season. Each of the pound netters included in the requested amendment participated in the study in the past and agreed to some general handling and transport guidelines outlined by NMFS, including keeping the turtle moist, protecting them from extreme heat by keeping them out of the direct sunlight, placing the animals on pads for cushioning, and making sure that the area around the animals is clear of any dangerous materials or objects. In addition, each approved waterman is required to carry a copy of the NMFS ESA permit on board their vessel at all times. The addendum was approved on by NMFS on August 8, 2003.

2. Determine distribution, migration patterns, and baseline health of sea turtles in Maryland's Chesapeake Bay.

A total of 23 sea turtles were examined in 2003 as part of the tagging and health assessment study. Twenty animals were "new" to the study and 3 were recaptures from either within a season or between seasons. Of the 20 new turtles, 13 were loggerheads and 7 were Kemp's ridleys. The thirteen loggerheads ranged in size from 60.2 to 94.1cm curved carapace length (ccl) and in weight from 53 to 160 pounds. The seven Kemp's ridleys examined ranged in size from 35.2 cm to 56.8 cm ccl and in weight from 9 to 42 pounds.

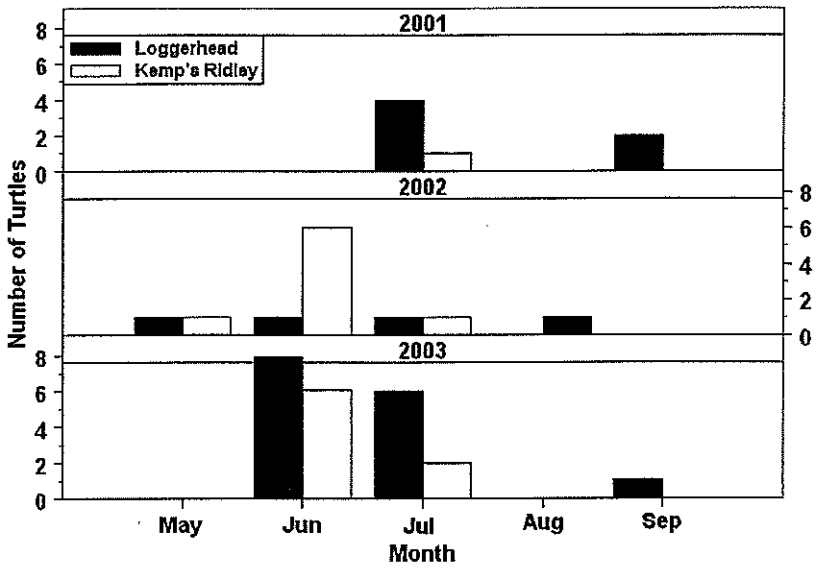

Figure 1. Monthly distribution of sea turtle incidental captures by species for 2001, 2002 and 2003 in Maryland's Chesapeake Bay.

The monthly and yearly distribution of incidental captures by species is given in Figure 1. The larger number of turtles examined in 2003 (compared to 2001 and 2002) may be the result of greater participation by commercial watermen. The 2001 season was truncated as the result of federal permitting issues and only 2 commercial watermen participated in the study, reporting a total of 7 turtles that year. In 2002 three commercial watermen participated in the study and we examined a total of 12 turtles. The 2003 reports came from five pound netters; one with nets located northwest of Hooper's Island, the second with nets located east of Clay Island in Fishing Bay, the third with nets located in Pocomoke Sound, the fourth with nets in the mouth of the Choptank River and the fifth with nets west of Kent Island. Three of the five pound netters were new participants in the tagging study. The turtles were found in a total of eight different nets (Table 1): the captures in Fishing Bay, Pocomoke Sound and the mouth of the Choptank were each from a single net location, while captures northwest of Hoopers Island occurred in three different nets registered to the same individual pound netter and captures west of Kent Island occurred in 2 different nets registered to the same pound netter.

Table 1. Distribution of incidental captures of sea turtles among net sites for 2003. Numbers in parentheses indicate recaptures. See text for details.

Net Site	# of nets	CCA	LKE	Total
NW of Hoopers Island	3	8 (1)	5 (1)	13
Pocomoke Sound	1	2		2
Fishing Bay	1		1	1
Choptank River	1	1	1	2
Kent Island	2	2 (1)		2
Totals	**8**	**13(2)**	**7(1)**	**20(3)**

Two of the 20 sea turtles tagged in 2003 were recaptured in the Bay, near the point of their original release. A kemp's ridley tagged in the mouth of the Choptank River on June 21, 2003 was recaptured a week later in a pound net northwest of Hoopers Island, indicating that the

animal traveled south about 10 miles after being released. A loggerhead found in one of the three pound nets northwest of Hoopers Island was tagged and recaptured in a different net in the same general location several days later. The recaptures were documented and the animals were released. No morphometric data was collected on these animals due to the extremely short period of time between captures. However, in the future morphometrics (length and weight) will be taken on all turtles recaptured in the same season regardless of the time between captures. These extremely limited recapture records suggest restricted turtle movements within the Bay during the summer.

A Maryland loggerhead sea turtle (01-PN-CC-03) tagged and released from a pound net near Kent Island in July 2001 was recaptured in the same location on September 15, 2003. The turtle, had tag scars on the posterior edge of both front flippers, indicating that at one time it had been tagged. A PIT tag scan revealed an identification number that we were able to match to our database. We collected morphometric information as well as a blood sample to compare with data collected from this animal in 2001. In a little over two years, the turtle had grown more than 4 cm in length, from 90.0 cm curved carapace length (ccl, notch to tip) to 94.2 cm ccl, and 3 cm in width, from 81.1 cm curved carapace width (scw) to 84.1 cm ccw. A metal Inconel tag was inserted into the third scale on the posterior edge of the left front flipper to aid in identification of this animal in the future. This is the first recapture of an animal between seasons in this study and demonstrates site fidelity by a subadult loggerhead over multiple, but not necessarily consecutive, years.

A total of 42 sea turtles have been examined since the inception of the Maryland Sea Turtle Tagging and Health Assessment Study in the summer of 2001 (Table 2). Three of 42 animals were recaptures from this project (discussed earlier). Seventeen of the remaining 39 turtles were Kemp's ridleys and 22 were loggerheads. The Kemp's ridleys ranged in size from 31.9 to 56.8 cm ccl and in weight from 7 to 42 pounds and the loggerheads ranged in size from 51.9 to 105.0 cm ccl and in weight from 55 to approximately 300 pounds (Figure 2).

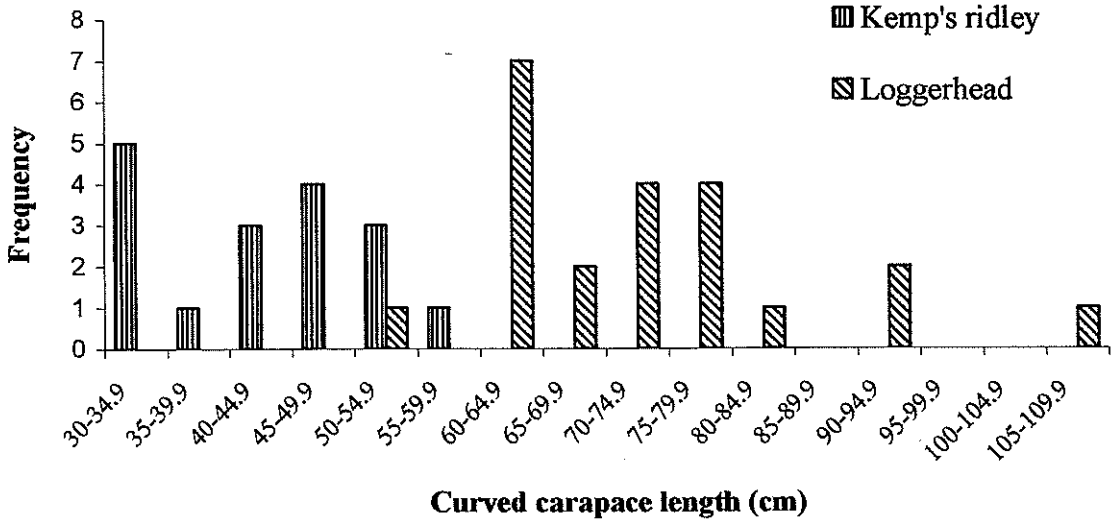

Figure 2. Size frequency distribution of loggerhead and Kemp's ridley sea turtles examined in the pound net tagging and health assessment study, 2001 to 2003.

Incidental captures took place between May and September over the three year period of the study (Figure 1) and occurred from Kent Island in Maryland's middle Chesapeake Bay to Pocomoke Sound in Maryland's lower Chesapeake Bay (Figure 3; Table 2). While turtles were distributed widely throughout much of the Bay, they were more concentrated west of Hoopers Island and near the mouth of Fishing Bay. However, it is important to note that the distribution of animals most likely reflects capture effort rather than distribution of free ranging turtles. For example, the concentration of turtles near Hoopers Island may be a reflection of increased reporting of incidental captures by watermen fishing in that area. This particular waterman has participated in the study in all three years, whereas the remaining six watermen participated in only one or two years of the study. In addition, the biased sampling effort and small sample size thus far preclude an estimation of absolute sea turtle abundance in Maryland waters. Therefore, at best, these results give an indication of relative distribution in Maryland waters of the Chesapeake Bay. Systematic aerial surveys, conducted over several years and in conjunction with the pound net tagging study, are needed to determine sea turtle distribution and abundance in the Chesapeake Bay.

Several recaptures were documented during the period of the study. Four of the 39 turtles tagged between 2001 and 2003 were recaptured in the Bay. Three of the turtles were recaptured in 2003 and were described in detail in an earlier section. The fourth turtle, a loggerhead, was originally tagged in our study on May 23, 2002 and recaptured in a pound net in Virginia waters of the Potomac River (St. Mary's county) on August 15, 2002. The animal was released unharmed by the watermen and no measurements were taken (K. Mansfield, VIMS, pers. comm.). We have only encountered one animal that was originally tagged elsewhere. This animal, a loggerhead, was incidentally captured in a pound net near Hoopers Island in 2001 and had a flipper tag in the right front flipper. The University of Central Florida had originally tagged her on July 23, 1992 on Melbourne Beach, Brevard County, Florida, after laying a clutch of 85 eggs. Although many years had elapsed between original tagging and recovery, this is evidence of a long distance migration (approximately 1500 km) to Chesapeake Bay by an adult female loggerhead. In nine years she had grown only 4 cm in length, from 101.1-cm ccl to 105.0 cm ccl, and 9 cm in width, from 84.9 cm ccl to 93.8 cm ccl. In comparison, the turtle tagged in 2001 and recaptured in 2003 (01-PN-CC-03) grew 4 cm (90.0 cm to 94.2 cm ccl) in just over two years. This evidence is not surprising as research has shown that loggerhead growth rates (cm/year) decrease as carapace length increases, or as animals get older (Bolten 2003). Data from tag returns like the ones described above will continue to provide insight into the distribution, growth rates and overall long distance movements of sea turtles tagged in this study.

The Chesapeake Bay has been identified as an important developmental habitat for loggerheads and Kemp's ridleys, particularly juveniles, in the summer months. The occurrence of incidental captures during the summer and early fall coincides with the seasonal migration pattern of loggerheads and Kemp's ridleys into the Chesapeake Bay, with immigration in late May or early June and emigration in September and October (Lutcavage and Musick 1985; Keinath et al. 1994). Keinath et al. (1994) examined 202 live (mostly from pound net captures) or dead Kemp's ridleys in Virginia waters between 1979 and 1993 and found that ridley turtles most often encountered were 30 to 40 cm subadults, with a mean size of 40 cm ccl. In addition, they found that most strandings and live captures occurred in May and June. Forty-one percent (n=7) of the Kemp's ridleys we examined between 2001 and 2003 were 30 to 40 cm ccl and 35% (n=6)

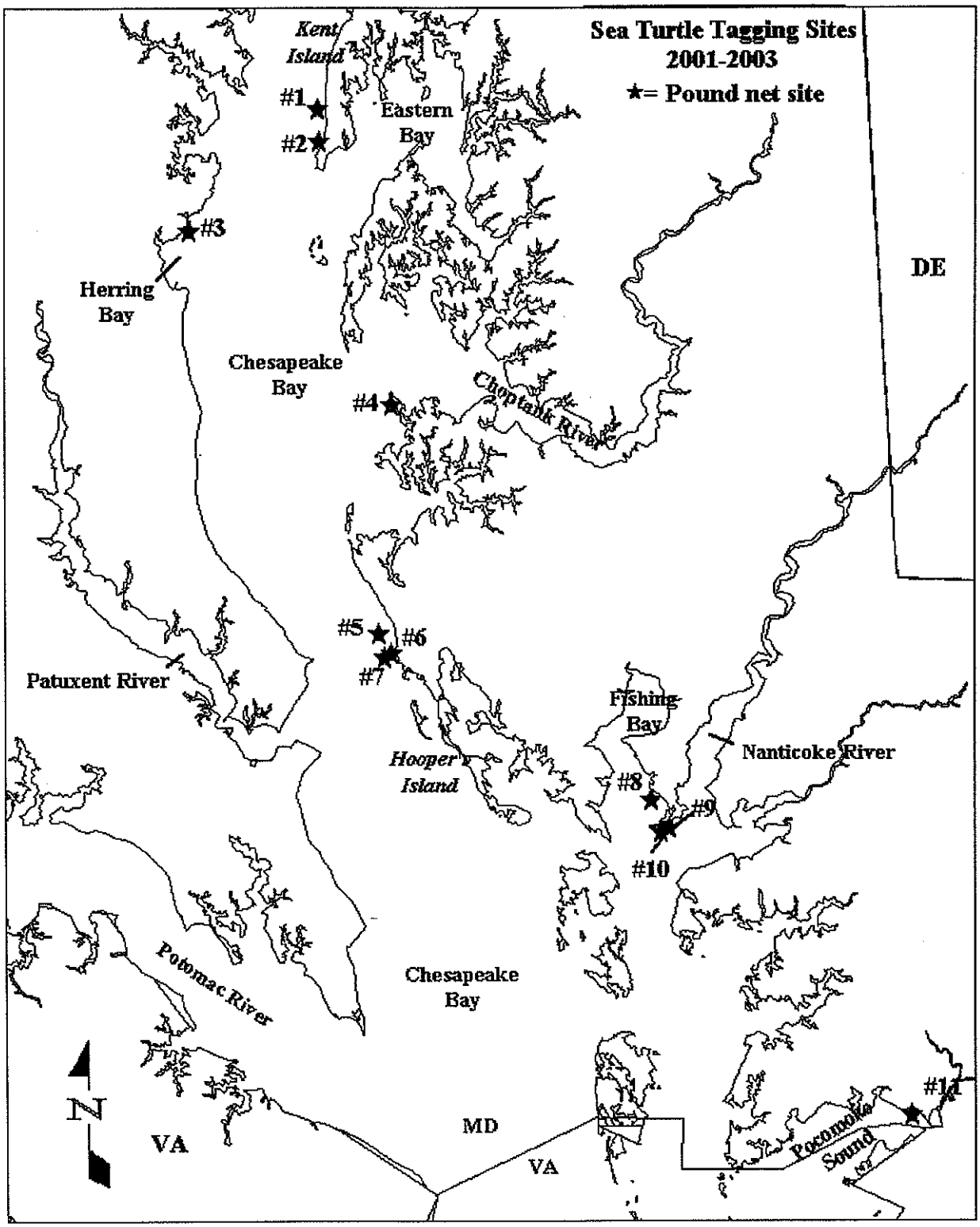

Figure 3. Pound net sites in Chesapeake Bay in which incidentally captured sea turtles were examined and tagged, 2001-2003. Refer to Table 2 for data on sea turtles at each net site.

Table 2. Summary of data collected during the Maryland sea turtle tagging and health assessment study from 2001-2003 by pound net site.

Pound Net Site No. & Location	Species	Accession No.	Exam Date	Straight length (notch to tip) cm	Curved length (notch to tip) cm	Straight width (cm)	Curved width (cm)	Weight (lbs)	Flipper Tagged?	Blood Sample?	PIT Tagged?
1 38° 53' 38" 76° 22' 31"	*Caretta caretta*	01-PN-CC-03*	7/18/01	83.0	90.0	67.6	81.1	150.0	Y	Y	Y
	Caretta caretta		9/15/2003	88.7	94.2	69.9	84.1	~350	Y	Y	N
	Caretta caretta	01-PN-CC-06	9/5/01	64.6	72.0	54.2	65.4	77.5	Y	Y	Y
	Caretta caretta	03-PN-CC-17	7/24/03	69.3	73.0	58.9	70.5	112.0	Y	Y	Y
2 38° 51' 51" 76° 22' 28"	*Caretta caretta*	01-PN-CC-04	7/20/01	62.1	71.0	50.4	66.0	83.0	Y	Y	Y
	Caretta caretta	01-PN-CC-05	7/26/01	66.2	75.4	57.4	70.0	112.0	Y	Y	Y
	Caretta caretta	01-PN-CC-07	9/6/01	74.0	80.0	67.0	76.0	140.0	Y	Y	Y
	Caretta caretta	03-PN-CC-15	7/15/03	87.0	94.1	67.2	89.3	160.0	Y	Y	Y
3 38° 46' 52" 76° 31' 30"	*Caretta caretta*	02-PN-CC-09	6/28/02	47.6	51.9	38.7	48.9	55.0	Y	Y	Y
4 38° 37' 11"	*Lepidochelys kempi*	03-PN-LK-08	6/21/03	34.0	35.2	31.3	35.3	9.0	Y	N	Y
	Caretta caretta	03-PN-CC-16	7/21/03	66.5	73.0	55.7	69.0	82.0	Y	Y	Y
5 38° 24' 23" 76° 18' 06"	*Lepidochelys kempi*	01-PN-LK-01	7/13/01	48.5	54.1	46.3	54.2	23.0	Y	Y	Y
	Caretta caretta	01-PN-CC-02	7/13/01	97.4	105.0	75.4	93.8	300.0	Y^	Y	N
	Lepidochelys kempi	03-PN-LK-01	6/11/03	50.8	52.7	48.5	54.0	18.0	Y	N	Y
	Caretta caretta	03-PN-CC-07	6/20/03	60.4	64.7	55.8	64.1	78.0	Y	Y	Y
	Caretta caretta	03-PN-CC-09	6/25/03	55.3	60.2	48.3	59.3	53.0	Y	Y	N
	Lepidochelys kempi	03-PN-LK-13	7/11/03	50.1	51.5	45.6	52.0	30.0	Y	Y	Y
	Caretta caretta	03-PN-CC-14	7/11/03	57.7	63.2	48.7	57.6	59.0	Y	Y	Y
	Caretta caretta	03-PN-CC-18	7/31/03	74.1	77.0	61.0	79.0	128.0	Y	Y	Y
	Lepidochelys kempi	03-PN-LK-08**	6/30/2003	NT	NT	NT	NT	NT	N/A	N/A	N/A
6 38° 23' 27" 76° 17' 20"	*Caretta caretta*	03-PN-CC-05	6/20/03	60.3	63.9	61.2	63.4	70.0	Y	Y	Y
	Lepidochelys kempi	03-PN-LK-06	6/20/03	52.7	56.8	49.9	53.8	42.0	Y	Y	Y
	Caretta caretta	03-PN-CC-10	6/25/03	57.1	61.5	50.5	60.2	72.0	Y	Y	Y
	Caretta caretta	03-PN-CC-12	6/30/03	70.2	75.1	55.6	69.3	84.0	Y	Y	Y
	Caretta caretta	03-PN-CC-09**	6/30/2003	NT	NT	NT	NT	NT	N/A	N/A	N/A
7 38° 23' 01" 76° 17' 44"	*Caretta caretta*	02-PN-CC-01	5/23/02	59.6	62.5	48.1	57.1	73.0	Y	Y	Y
	Lepidochelys kempi	02-PN-LK-02	5/23/02	45.7	49.4	42.8	51.2	25.0	Y	Y	Y
	Lepidochelys kempi	03-PN-LK-11	6/30/03	38.2	40.0	35.3	39.3	16.0	Y	Y	Y
	Lepidochelys kempi	03-PN-LK-19	7/31/03	45.5	48.7	42.7	48.7	25.0	Y	Y	Y
	Caretta caretta	03-PN-CC-20	7/31/03	61.1	66.1	49.3	63.4	58.0	Y	Y	Y
8 38° 15' 13" 75° 58' 59"	*Lepidochelys kempi*	03-PN-LK-03	6/16/03	39.8	41.8	34.7	40.0	16.0	Y	Y	Y
9 38° 13' 40" 75° 57' 44"	*Lepidochelys kempi*	02-PN-LK-06	6/14/02	44.8	47.2	38.0	46.7	25.0	Y	Y	Y
10 38° 13' 26" 75° 58' 20"	*Lepidochelys kempi*	02-PN-LK-03	6/14/02	31.4	34.2	27.1	32.4	8.5	Y	Y	Y
	Lepidochelys kempi	02-PN-LK-04	6/14/02	29.8	31.9	26.7	31.5	7.0	N	Y	Y
	Lepidochelys kempi	02-PN-LK-05	6/14/02	31.4	33.3	27.9	33.3	10.0	Y	Y	Y
	Lepidochelys kempi	02-PN-LK-07	6/28/02	NE	34.9	NE	35.1	12.5	N	Y	Y
	Lepidochelys kempi	02-PN-LK-08	6/28/02	NE	32.0	NE	31.1	11.0	N	Y	Y
	Lepidochelys kempi	02-PN-LK-10	7/8/02	41.4	44.1	37.4	42.8	15.0	Y	Y	Y
	Caretta caretta	02-PN-CC-11	7/29/02	70.4	76.8	57.4	72.6	92.0	Y	Y	Y
	Lepidochelys kempi	02-PN-LK-12	8/12/02	42.4	47.0	39.8	49.3	19.5	Y	N	Y
11 37° 57' 31"	*Caretta caretta*	03-PN-CC-02	6/12/03	62.8	65.2	47.1	59.3	60.0	Y	Y	Y
	Caretta caretta	03-PN-CC-04	6/16/03	56.7	64.5	46.0	61.0	61.0	Y	Y	Y

^ = Previously tagged *Recapture between seasons **Recapture within a season

of the turtles were 40 to 50 cm. Mean size was 42.9 cm ccl (SD=7.95). Lutcavage and Musick (1985) examined 312 live (from pound net captures) or stranded loggerheads in Virginia waters between 1979 and 1981 and found that curved carapace lengths ranged from 21.6 to 122.0 cm, with a mean size of 74.0 cm ccl. The mean size of loggerheads in this study was 72.1 cm ccl, which is similar to Lutcavage and Musicks' findings, but smaller than the average size of dead stranded loggerheads examined in Maryland from 1991 to 2003 (x=77.8, N=308).

3) Determine regional population structure and geographical origin of individual sea turtles found in the Chesapeake Bay.

Thirty-two tissue samples have been collected from incidentally captured sea turtles for genetic analysis. I contacted Dr. Peter Dutton of the NMFS Southwest Fisheries Science Center in La Jolla, CA in May 2002 to discuss establishing a cooperative agreement to analyze genetic samples collected in this study. Dr. Dutton expressed an interest in collaborating once a suitable sample size (about 100 individuals) is reached. More recently, I spoke with Robin Leroux, who also works in the NMFS Genetics Laboratory, about sending our archived samples to the lab so they can begin analyzing them as they have time. I am awaiting her response as she needed to discuss this proposal with Dr. Dutton. Until we receive an answer, samples will be archived at the COL. We looked into the possibility of combining our samples with those collected for other live animals studies in the region, but the only other study being conducted in the Chesapeake Bay (VIMS mark/recapture study) does not collect tissue samples for genetic analysis.

4) Compare tagging and blood work results with data collected from the Lower Chesapeake Bay and other studies along the Atlantic Coast of the United States.

A summary of the blood work analyses loggerheads and Kemp's ridleys from our study as well three other in-water studies conducted along the East Coast of the United States are given in Tables 3 and 4. There were some differences in the templates used by Antech (the lab that analyzed 2003 samples) and AniLab (the lab that analyzed the 2001 and 2002 samples and was bought out by Antech in 2002) to analyze our blood samples. Therefore, only those parameters that overlapped between labs are reported in Tables 3 and 4. The function and significance of each parameter are summarized in Table 5. As the data show, mean values for hematology and blood chemistry parameters are similar in many cases between studies and species (e.g., albumin, calcium, glucose), but there are also a number of differences that may be significant (e.g., AST, uric acid, CPK). Some of these differences in normal chemistry values may be attributed to variations between species. In addition, within species, normal values may vary with the geographical location of the sampled animals, the time of year (Lutz and Dunbar-Cooper 1987), age, diet, or an animal's activity (George 1997; Bolten and Bjorndal 1992). Although we have begun to compile hematology and blood chemistry values for wild sea turtles, additional samples, particularly for Kemp's ridleys, are needed to establish normal values for turtles in the Chesapeake Bay. Overtime, we hope that the results of this study will aid in establishing normal ranges for sea turtles along the Atlantic Coast of the United States.

Table 3. Hematology and blood chemistry values for wild loggerhead sea turtles from several in-water surveys along the East Coast of the United States.

		Chesapeake Bay Maryland[1]			South Carolina[2]			Chesapeake Bay Virginia[3]		
Species	**Parameter**	**n**	**Mean**	**StdDev**	**n**	**Mean**	**StdDev**	**n**	**Mean**	**StdDev**
Loggerhead	Albumin (g/dL)	21	1.32	0.49	37	1.33	1.46	50	1.3	1.1
	AST (IU/L)	21	172.24	96.45	37	259.49	125.48	50	285	120
	Basophils	21	0.67	1.02	43	0.05	0.21	----	----	----
	Calcium (mg/dL)	21	7.26	1.21	37	7.95	1.46	50	7.7	1.3
	CPK (IU/L)	21	1884.52	3051.18	37	3440.41	11590.76	50	1680	2043
	Eosinophils	21	3.14	13.07	43	0.00	0.00	----	----	----
	Globulin (g/dL)	21	2.29	0.51	36	3.44	0.74	----	----	----
	Glucose (mg/dL)	21	97.86	46.14	37	108.76	30.39	50	100	18
	HCT (%)	20	35.25	7.55	36	33.39	5.15	50	29	5
	Heterophils	21	64.81	22.01	43	44.98	17.60	----	----	----
	LDH, Serum (IU/L)	9	375.89	119.54	----	----	----	50	310	484
	Lymphocytes	21	30.10	23.04	43	53.23	18.22	----	----	----
	Monocytes	21	1.05	1.24	43	1.72	1.75	----	----	----
	Parasites	15	0	0	43	0	0.00	----	----	----
	Phosphorus (mg/dL)	21	8.10	1.83	37	7.15	1.36	50	5.9	1.3
	Tprot, Serum (g/dL)	21	3.61	0.82	37	4.62	1.03	50	3	1.1
	Uric Acid (mg/dL)	21	0.67	0.46	37	2.61	3.58	----	----	----
	WBC (K/uL)	21	8.22	2.98	43	11.33	5.12	----	----	----

[1]T. Kimmel, unpublished data

[2] A. Segars, South Carolina DNR, unpublished data

[3] Adapted from George (1997)

Table 4. Hematology and blood chemistry values for wild Kemp's ridley sea turtles from several in-water surveys, including this study, along the East Coast of the United States.

		Chesapeake Bay-Maryland[1]			South Carolina[2]			New York Bight[3]		
Species	**Parameter**	**n**	**Mean**	**StdDev**	**n**	**Mean**	**StdDev**	**n**	**Mean**	**StdDev**
Kemp's ridley	Albumin (g/dL)	12	1.38	0.24	1	1.2	----	60	1.3	0.2
	AST (IU/L)	12	206.31	100.26	1	172	----	60	145	42
	Basophils	11	0.00	0.00	2	0	0.00	----	----	----
	Calcium (mg/dL)	12	8.02	1.15	1	7.8	----	60	7.4	0.1
	CPK (IU/L)	13	1899.50	2230.60	1	1494	----	60	4460	3074
	Eosinophils	11	0.36	0.81	2	0	0.00	----	----	----
	Globulin (g/dL)	12	1.86	0.52	1	2.4	----	----	----	----
	Glucose (mg/dL)	12	89.15	30.71	1	56	----	60	115	42
	HCT (%)	11	38.50	12.49	1	34	----	60	31.1	13.5
	Heterophils	11	51.36	20.01	2	26.5	3.54	----	----	----
	LDH, Serum (IU/L)	9	930.33	358.74	----	----	----	60	1299	638
	Lymphocytes	10	43.64	23.16	2	71	7.07	----	----	----
	Monocytes	11	11.09	32.82	2	2.5	3.54	----	----	----
	Parasites	9	0.00	0.00	2	0	0.00	----	----	----
	Phosphorus (mg/dL)	12	8.15	1.99	1	10.7	----	60	6.8	1.4
	Tprot, Serum (g/dL)	12	3.25	0.67	1	3.6	----	60	3.1	0.5
	Uric Acid (mg/dL)	12	0.89	0.42	1	2.4	----	----	----	----
	WBC (K/uL)	10	7.80	3.42	2	16	12.73	----	----	----

[1]T. Kimmel, unpublished data

[2] A. Segars, South Carolina DNR, unpublished data

[3] Adapted from George (1997)

Table 5. Summary of function and significance of blood parameters analyzed as part of sea turtle tagging and health assessment study (summarized from Duncan and Prasse (2003)).

Parameter	Definition/Function	Significance
Albumin	-major constituent of serum protein made by liver -aids in osmotic pressure regulation, nutrient transport and waste removal	-↑ levels due to dehydration -↓ levels due to poor diet, infection, liver disease
Aspartate amino transferase (AST)	-enzyme found primarily in the liver, heart, kidney, pancreas and muscles	-↑levels typically associated with liver or muscle injury or disease
Basophils	-type of white blood cell -releases anticoagulants in inflammatory response	
Calcium	-most abundant mineral -involved in bone metabolism, protein absorption, blood clotting and cardiac function.	-number may ↑ in certain myeloproliferative disorders (too many blood cells in bone marrow)
Creatine phosphokinase (CPK)	-enzyme found predominately in the muscle, brain and heart.	-↑ levels indicate stress of injury to one of these areas
Eosinophils	-type of white blood cell -participates in allergic reactions and certain parasitic infections	
Globulin	-protein involved in immunologic responses as it carries some hormones, lipids, metals and antibodies	-↑ levels in chronic infections, liver disease
Glucose	-primary source of energy for most cells	-↑ levels in liver disease and during stress
Hematocrit (HCT)	-measurement of % of red blood cells in whole blood	-important determinant of anemia (↓), dehydration (↑), increased RBC breakdown in spleen (↓)
Lactic dehydrogenase (LDH)	-intracellular enzyme in kidney, hart, muscle, brain, liver and lungs	-↑ activity may result from hemolysis, muscle damage or hepatocellular injury
Lymphocytes	-type of white blood cell -secretes antibodies for immune responses	-↑ levels indicate infection
Monocytes	-type of white blood cell -ingests bacteria, dead cells and debris	
Phosphorus	-abundant element found in most tissues and cells -needed for buffering action, calcium transport and osmotic pressure	-abnormal levels caused by altered dietary concentrations, -↓ renal excretion and hormonal imbalances
Total Protein	-most abundant compound in serum	-↑ levels in liver disease, chronic infections -↓ levels in poor nutrition, liver disease, malabsorption
Uric Acid	-end product of purine metabolism	-↑ levels in gout, infections, kidney disease -↓ levels may indicate malabsorption or liver damage
White Blood Cell Count (WBC)	-fight infection, defend body against foreign organisms, produce antibodies in immune response	-↑ levels indicate infection

5) Summarize and analyze historical and current sea turtle stranding information for Maryland waters

The Marine Mammal and Sea Turtle Stranding Program was established at the Cooperative Oxford Laboratory (COL) in the fall of 1990. The network is responsible for the retrieval and examination of all dead stranded marine mammals and sea turtles in Maryland. Sea turtle strandings are typically reported to the Natural Resources Police 24-hour hotline, other state or federal agencies or private citizens and the calls are dispatched to stranding network participants at the COL. The stranding network collects species identification, stranding location and life history (morphometric) data and investigates causes of death, especially to assess human interaction from boat strikes, fisheries interactions, and entanglement or ingestion of marine debris. Stomach contents are evaluated when possible for feeding activity, prey composition and ingestion of plastics or other foreign objects. Necropsies are conducted on all animals when possible and samples are collected for histopathology, microbiology, toxicology, and virology from fresh carcasses. The network fills sample requests from researchers around the country and investigates or cooperates with other investigators in disease and toxicological studies. The program contributes to state research interests as well as national concerns through the dissemination of database information and distribution of parts catalogued and processed from stranded animals. Significant efforts are made towards conservation and recovery of these species through extensive outreach and educational programs in which staff deliver oral presentations to civic, school and other groups and organizations, participate in public outreach events, and publish printed information for distribution.

Methods

Sea turtle stranding data collected from 1991 to the present was entered into a Microsoft Access database at the COL. Historical data on sea turtles strandings is generally lacking, as there was no consistent effort to collect information on stranded turtles before the inception of the Maryland program in the fall of 1990.

Carapace lengths of stranded turtles were measured with a flexible measuring tape (curved length) or with calipers (straight length). Curved carapace measurements, taken from the nuchal notch to the posterior marginal tip of the carapace, were used in the size frequency analysis. If only straight measurements were taken, straight carapace lengths (SCL) were converted to curved carapace lengths (CCL) for size classification using regression equations described in Teas (1993).

For the purposes of seasonal analysis, seasons were defined as follows: winter (December through February), spring (March through May), summer (June through August) and fall (September through November).

For gut content analysis items were initially categorized into 13 prey groups (lady crabs, whelk, fish, anthropogenic debris, etc.). Crab parts that were not identified to species in the database were categorized as "unidentified crab." The eight crab categories (broken down by species) were summed, resulting in a total of 6 prey categories (whelk, horseshoe crab, crab, fish, other and debris). The results are presented as percentage and absolute numbers for each prey group.

Results

Species Composition

Stranding network personnel at the COL responded to 308 dead stranded sea turtles in Maryland waters between 1991 and 2003. Yearly totals ranged from 13 to 48 sea turtles, with a peak in the number of strandings in 2002 (Figure 4). On average, 23.7 sea turtles stranded each year. The data indicate an overall increasing trend in sea turtle strandings over time, with the exception of 2003, in which an unusually low number of sea turtles stranded in Maryland.

The strandings consisted of four species: the loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*), Kemp's ridley (*Lepidochelys kempi*) and green (*Chelonia mydas)* sea turtles. The loggerhead was the most commonly stranded species, accounting for 89% (n=273) of the total number of strandings. Of the remaining strandings, seven percent (n=21) were leatherbacks, 3% (n=10) were Kemp's ridleys, 1% (n=3) were unidentified and less than 1% (n=1) were green sea turtles (Figure 4).

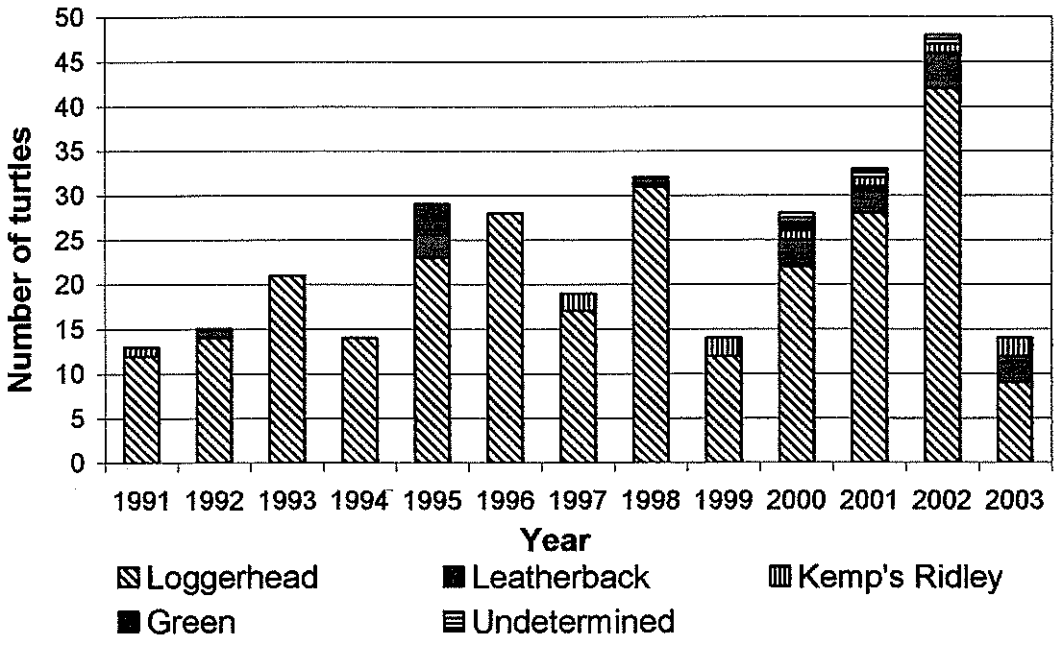

Figure 4. Sea turtle strandings in Maryland waters by year and species, 1991 to 2003.

Spatial and Temporal Distribution

Sea turtle strandings occurred in Maryland waters of the Chesapeake Bay and along Maryland=s Atlantic coastline and its coastal bays. As shown in Table 6, the total number of strandings was greater along the coastline than in the Chesapeake Bay for all species over the 13 year period, although Kemp's ridley strandings occurred almost equally along the coast (6) and within the Bay (4).

Table 6. Summary of total number of sea turtle strandings in Maryland from 1991 to 2003 according to geographic location.

Species	MD Atlantic Coast	Chesapeake Bay	Total
Loggerhead	161	112	273
Leatherback	15	6	21
Kemp's ridley	6	4	10
Unidentified	2	1	3
Green	1	0	1
Total:	185	123	308

Table 7 shows the location of sea turtle strandings by year for the 13 year period. Although the overall number of strandings was greater along the coast than in the Chesapeake Bay, there were some considerable differences in the number of loggerhead strandings in each location *between* years. Loggerhead strandings peaked in the Chesapeake Bay in 1995 (17) and 1998 (19) as compared to 6 and 12 strandings, respectively, along the coastline in the same two years. Conversely, in 2002 loggerhead strandings along the coastline peaked at 37, as compared to only 5 strandings in the Chesapeake Bay that year. In some years the number of loggerhead strandings occurred almost equally along the coast and within the Bay (e.g., 1994, 1996, 1997, 2003).

Table 7. Summary of sea turtle strandings by year and geographic location from 1991 to 2003. A dash (-) indicates that no strandings were reported. A=Atlantic coast and C=Chesapeake Bay.

Species	1991		1992		1993		1994		1995		1996		1997		1998		1999		2000		2001		2002		2003	
	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C
Loggerhead	8	4	9	5	9	12	8	6	6	17	14	14	10	7	12	19	9	3	14	8	21	7	37	5	4	5
Leatherback	-	-	0	1	-	-	-	-	3	3	-	-	-	-	1	-	-	-	2	1	3	-	4	-	2	1
Kemp's Ridley	-	1	-	-	-	-	-	-	-	-	-	-	1	1	-	-	2	-	-	1	1	-	1	-	1	1
Green	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	-	-	-
	8	5	9	6	9	12	8	6	9	20	14	14	11	8	13	19	11	3	18	10	25	8	43	5	7	7

Figure 5 shows the locations of all sea turtle strandings along the Atlantic Coast of Maryland for the 13 year period. The majority of the turtles were found along Assateague Island (n=124), which consists of Assateague Island State Park (n=9) and Assateague Island National Seashore (n=115) (Figure 6). Stranding occurred from the north tip of Assateague Island (just south of the Ocean City inlet) south to the Virginia border. A smaller number of sea turtle strandings were reported north of the island on the beaches of Ocean City (n=45) (Figure 7). Although turtles were found along much of the Ocean City beach, they tended to cluster in two areas, from 20th to 40th streets and again from about 87th to 140th Streets in north Ocean City (Figure 7). Strandings

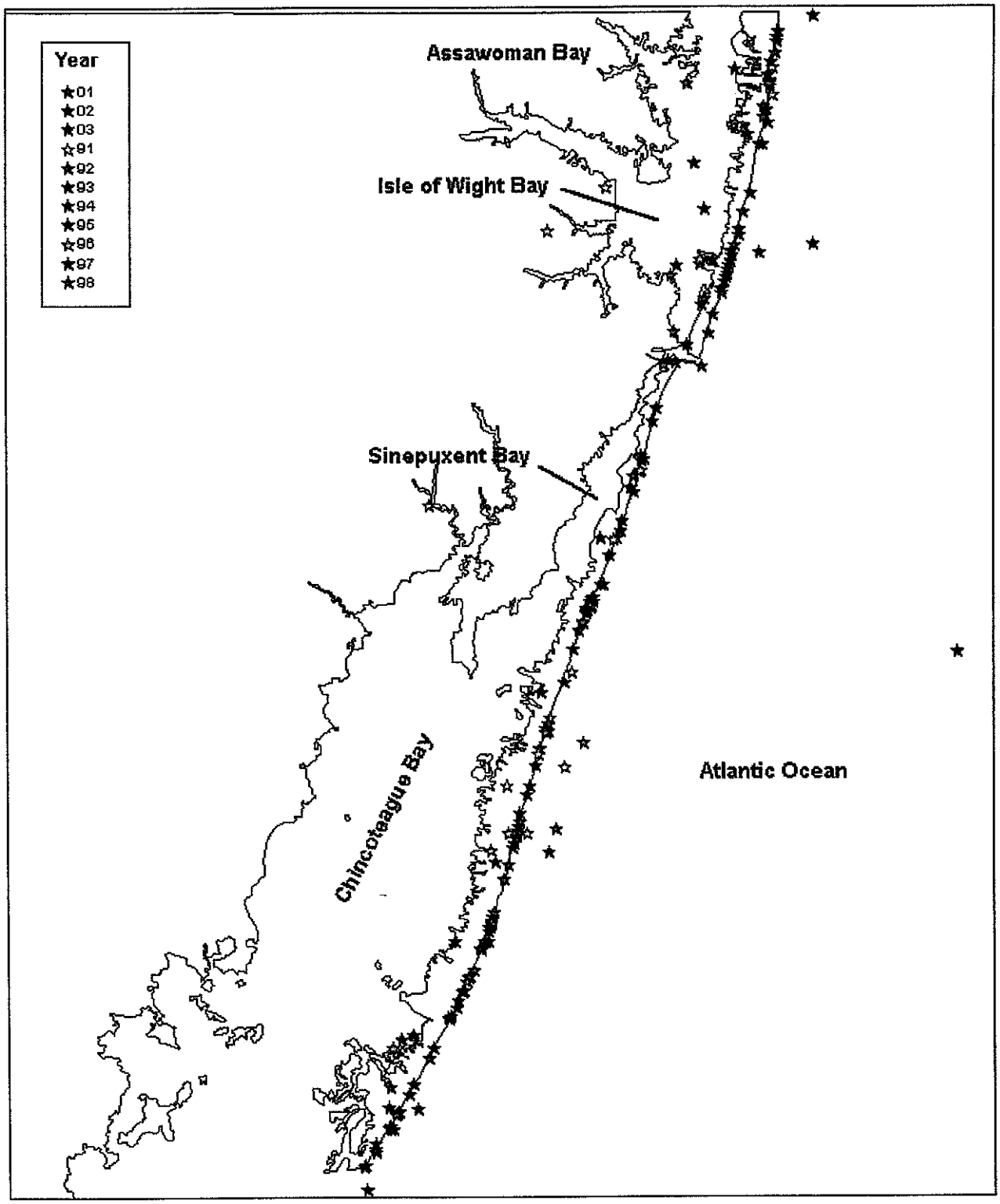

Figure 5. Locations of sea turtle strandings along Maryland's Atlantic Coast and coastal bays from 1991 to 2003. See text for details.

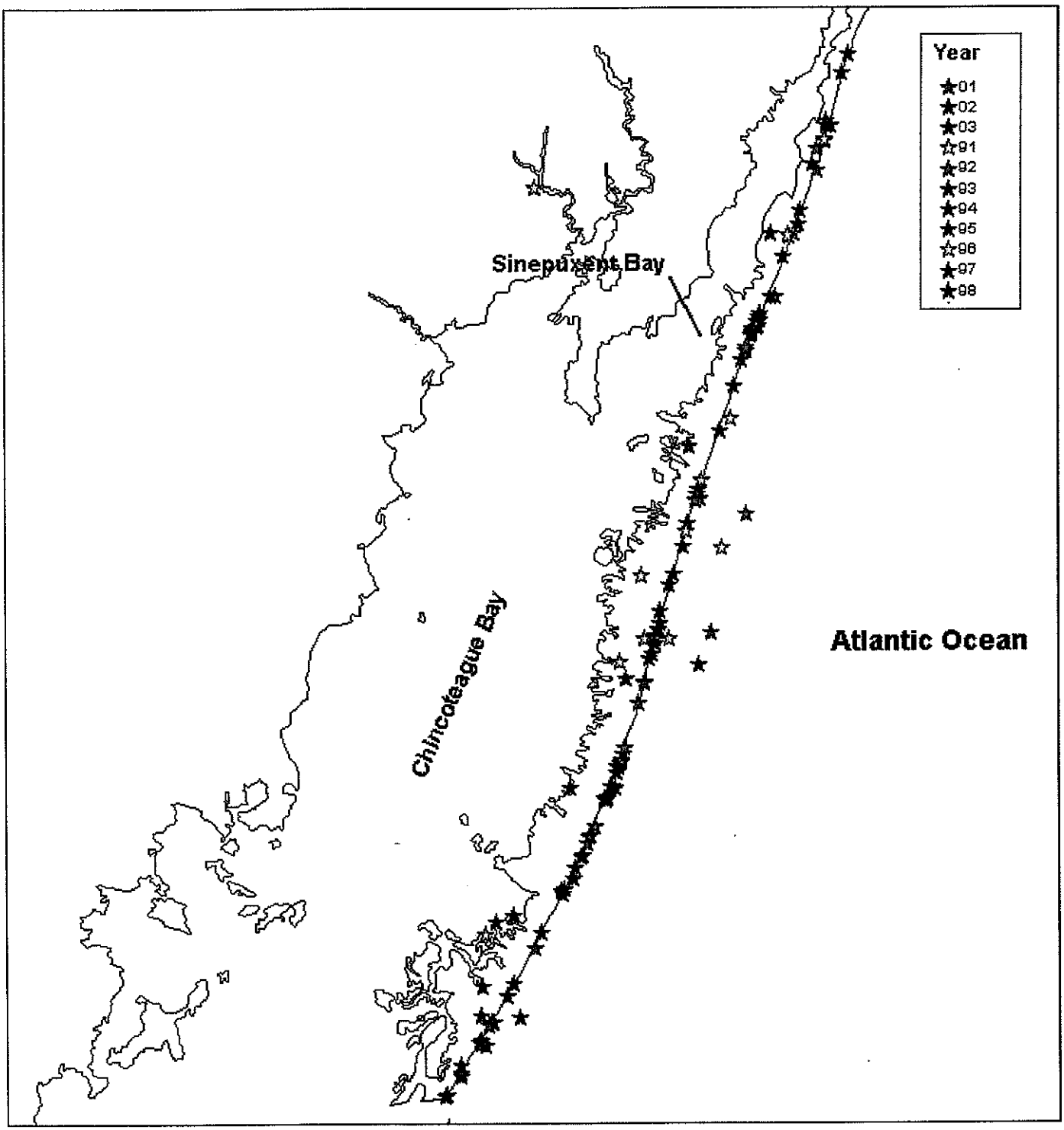

Figure 6. Locations of sea turtles strandings along Assateague Island National Seashore from 1991 to 2003. See text for details.

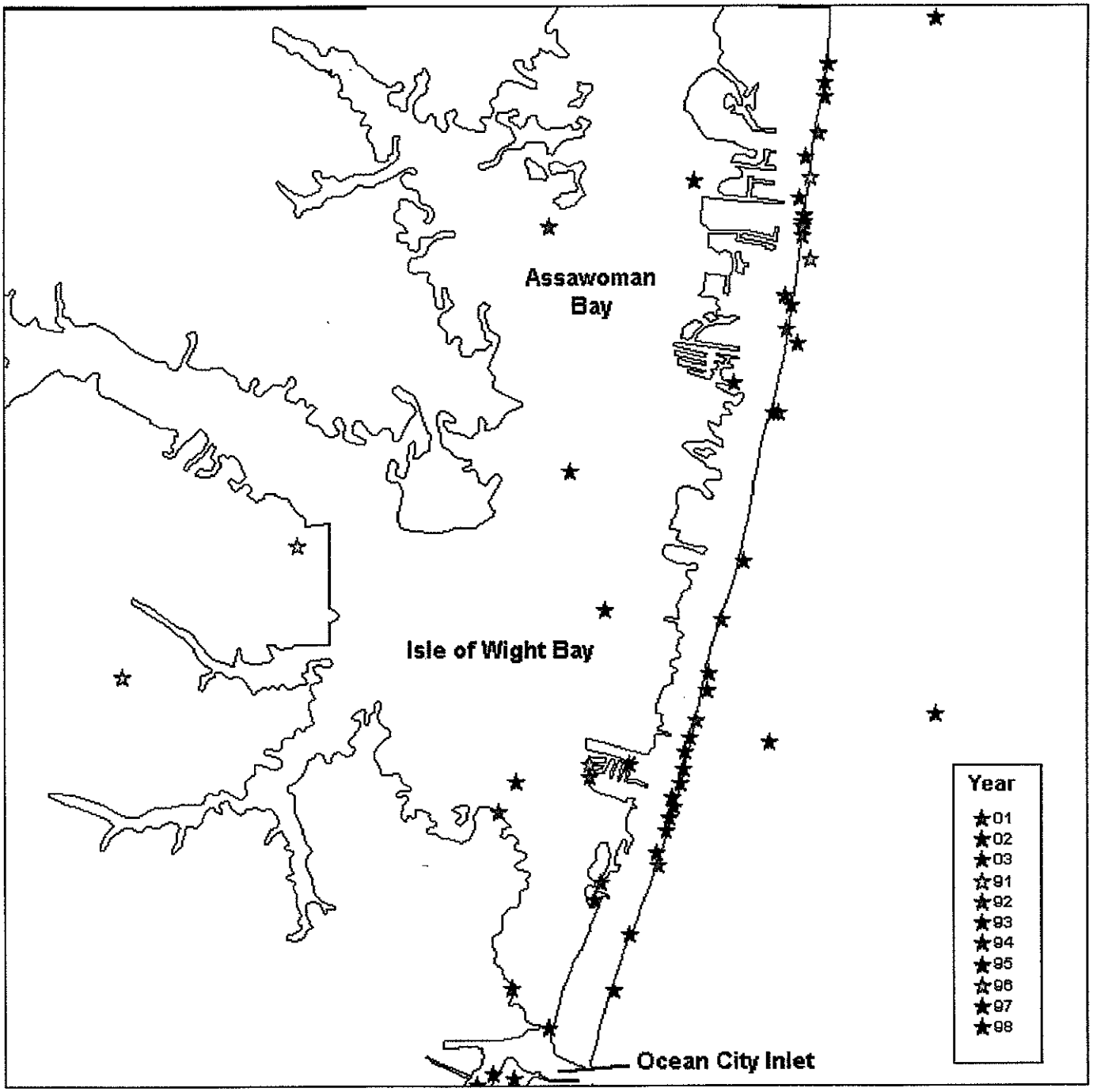

Figure 7. Locations of sea turtle strandings along the beaches of Ocean City, 1991 to 2003. See text for details.

were reported much less frequently from the coastal bays (n=17), with 4 strandings (3 loggerheads, 1 Kemp's ridley) occurring in Assawoman Bay, 6 (5 loggerheads, 1 Kemp's ridley) in Isle of Wight Bay, 5 (4 loggerheads, 1 green) in Sinepuxent Bay and 2 loggerheads in Chincoteague Bay (Figure 5).

Sea turtle strandings in the Chesapeake Bay were widespread, occurring from Tangier Sound in the lower Maryland portion of the Bay northward to the mouth of Back River in the upper Bay (Figure 8). Although strandings occurred throughout much of the Bay, they were most heavily concentrated in Calvert and Saint Mary's counties along the western shore. This may reflect the fact that turtles are more abundant in the lower portion of the Bay-more in VA.

Sea turtle strandings occurred from May to February for the 13 year period, with the majority occurring from May to October and a large peak in strandings in June (Figure 9). The peak in June comprised 38.6% (n=119) of the total strandings for all years combined, followed by July (15.3%) and September (14.9%). Loggerhead strandings occurred in all months from May to February and accounted for 94.1% (n=112) of the strandings in June. Leatherback strandings occurred in May through October and December with the highest number of strandings in September. Kemp's ridley strandings occurred from May to October and were fairly evenly distributed between those months. The green sea turtle stranded in October.

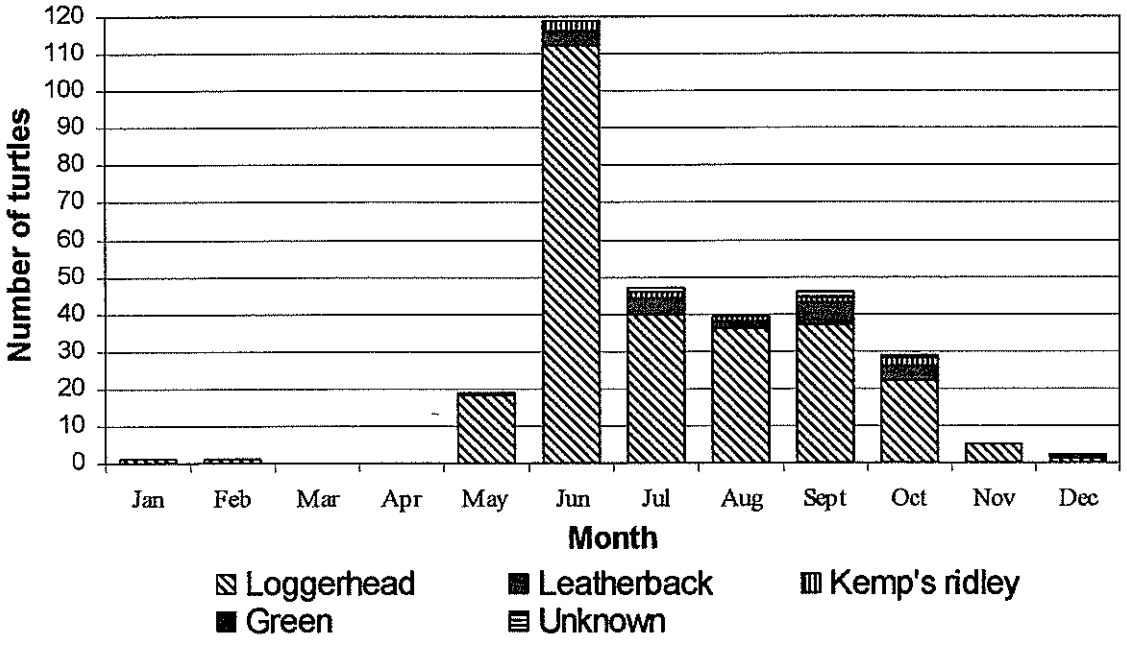

Figure 9. Sea turtle strandings in Maryland waters by month and species, 1991 to 2003.

Sea turtle strandings occurred during all seasons with 44.8% (n=138) occurring in the spring, 42.8% (n=132) in the summer, 11.7% (n=36) in the fall and less than 1% (n=2) in the winter (Figure 10). Loggerheads were the only species to strand in the winter and made up the majority of the strandings in the spring, summer and fall. Leatherback and Kemp's ridley strandings occurred in the spring, summer and fall and the green sea turtle stranded in the fall.

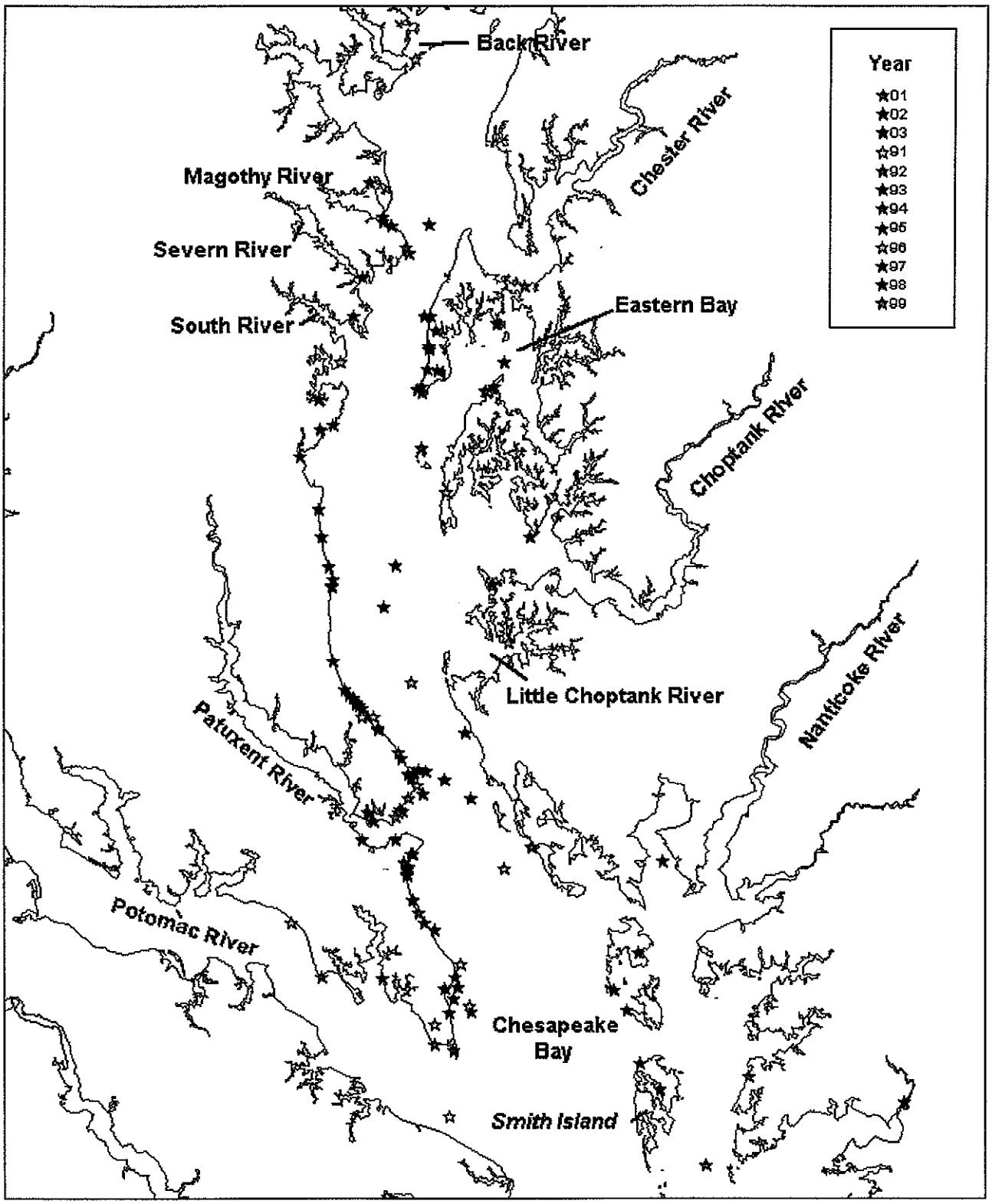

Figure 8. Locations of sea turtle strandings in Maryland portion of the Chesapeake Bay, 1991 to 2003. See text for details.

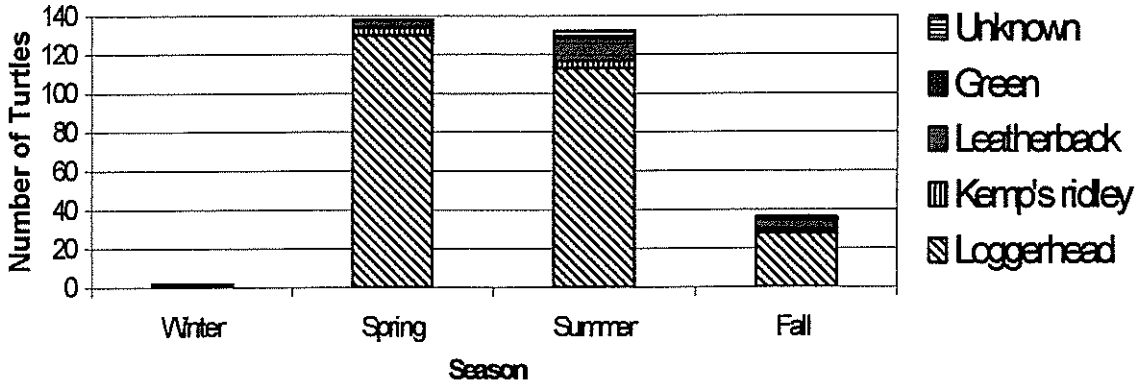

Figure 10. Sea turtle strandings in Maryland waters by season and species, 1991 to 2003.

Population Structure

The length-frequency distribution of stranded loggerhead sea turtles is shown in Figure 11. Curved carapace lengths ranged from 24.0 cm to 136.0 cm (N=241, mean = 77.8) and were bimodal in distribution. Based on size categories for loggerhead populations in the Chesapeake Bay (Klinger and Musick 1995) and the southeastern United States (Stoneburner 1980) the size distribution suggests the occurrence of both immature and adult turtles in Maryland waters, although immatures were the dominant size class. Using a mean size at maturity of 99.1 cm ccl (reported in Klinger and Musick 1995 as 92.5 cm scl and converted to ccl), approximately 81.7% (n=197) of the turtles were immature and 64.5% (n=127) of these turtles ranged from 60 to 80 cm ccl. Juveniles less than 50 cm ccl were rare in Maryland waters, which is consistent with findings that these animals do not begin to recruit to neritic habitats in the western Atlantic until they reach a size of about 46-50 cm ccl (Klinger and Musick 1995; Bjorndal et al. 2000).

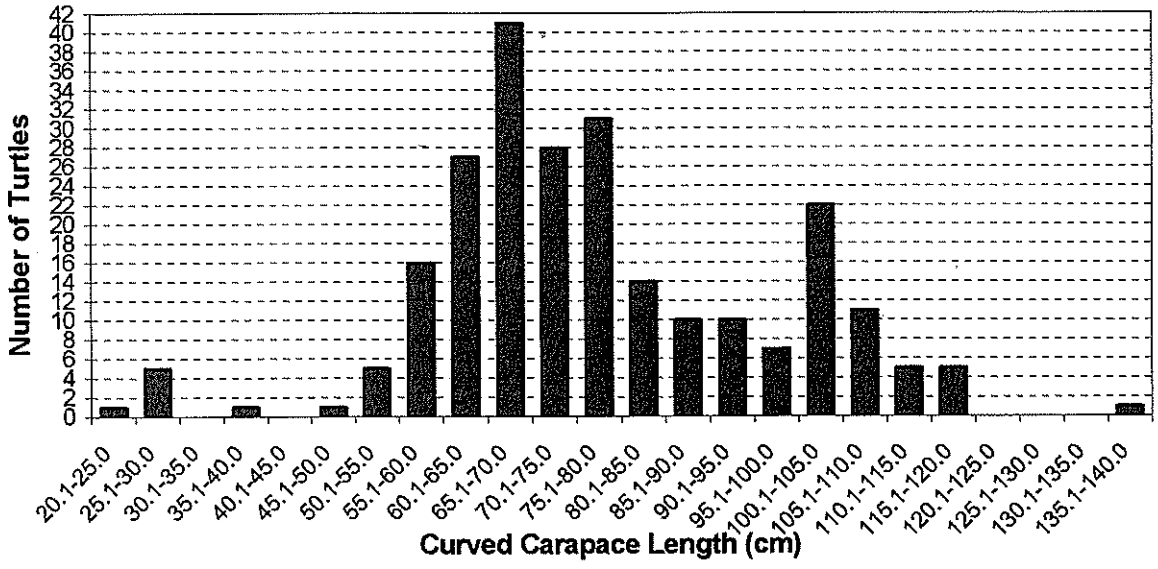

Figure 11. Size frequency distribution of loggerhead sea turtle strandings in Maryland waters from 1991 to 2003.

Of the 21 leatherback strandings for which curved measurements were taken the lengths ranged from 119.4 cm to 181.0 cm (N=16, mean = 151.1), with the majority falling between 135 and 160 cm. Using an average size of maturity of 157 cm ccl (based on the approximate average size of nesting females, Musick and Limpus 1997), the majority (75%) of leatherback strandings in Maryland were large juveniles (n=12).

The Kemp's ridleys ranged in size from 30.7 cm to 67.4 cm ccl (N=10, mean = 44.4 cm). Although the sample size is small, the turtles most often encountered were 30 to 40 cm ccl. Based on an adult size of 68.8 cm ccl (USFWS & NMFS 1992, converted from 65 cm scl to ccl), all but possibly one animal (67.4 cm ccl) were juveniles. The mean size of 44.4 cm ccl is similar to the mean size of 39.7 cm ccl reported by Keinath et al. (1994) for Kemp's ridleys in Virginia waters.

Necropsy Findings

Necropsies were conducted on 167 (54.2%) of the 308 dead stranded sea turtles reported between 1991 and 2003. Eighty-eight percent (N=147) of the necropsies were conducted on loggerheads, 6.6% (N=11) on leatherbacks, 4.8% (N=8) on Kemp's ridleys and 0.6% (N=1) on green sea turtles. Several factors prohibited COL Network personnel from completing necropsies on all stranded sea turtles: 1) animal condition--in many cases the animals were too decomposed to complete a necropsy; 2) location--some animal were floating or otherwise inaccessible to network members and 3) disposition--some animals were frozen for use at necropsy workshops or other teaching seminars.

Condition

The condition of 308 dead stranded sea turtles is shown in Table 8. Forty-eight percent of the turtles were recorded as moderately decomposed, 40.4% as severely decomposed, 8.5% as freshly dead, 3.3% as skeletonized or bones and less than 0.5% as a dried carcass. The condition of one loggerhead was unknown.

Table 8. State of decomposition of dead stranded sea turtles in Maryland from 1991 to 2003.

	Condition						
Species	**Fresh Dead**	**Moderately Decomposed**	**Severely Decomposed**	**Dried Carcass**	**Bones**	**Unknown**	**Total**
Loggerhead	25 (9%)	130 (48%)	108 (40%)	1 (<1%)	8 (3%)	1(<1%)	273
Leatherback	1	6	13	0	1	0	21
Kemp's ridley	0	8	2	0	0	0	10
Green	0	1	0	0	0	0	1
Unidentified	0	1	1	0	1	0	3
Total:	26	146	124	1	10	1	308

Gut contents

Gut contents were examined in 142 (46%) of the 308 dead stranded sea turtles reported between 1991 and 2003. A variety of items were observed including horseshoe crabs, whelk, fish, decapod crabs (lady, spider, blue, rock, etc.), sand, seagrasses and shells. Analysis of the stomach contents resulted in 212 total records (in many cases more than one type of item was recorded from a single stomach) that were categorized into 6 different prey groups (Table 9). Crabs constituted the highest ranked prey, occurring in 71.8% of the samples, followed by horseshoe crabs, whelk and fishes. Nine species of crabs were tentatively identified (Table 10), with lady crabs accounting for approximately 40% of the total crab prey group. Most fishes were too decomposed or digested to be identified to species. Most items in the "other" category, including sand, mud, snails and shells were most likely consumed incidentally from the benthos during feeding or as gut contents of other prey. Anthropogenic debris was present in 3.6% (n=5) of the digestive tracts examined during the 13 year period and was only found in loggerhead sea turtles. Debris consisted of pieces of plastic bag, fish hooks, and hook, line and sinkers and were found in the esophagus, stomach and intestinal tract.

Table 9. Percent occurrence of prey items identified from digestive tract contents of sea turtles (n=142).

Prey Group	Percent Occurrence	N
Crabs	71.8	102
Horseshoe crabs	26.8	38
Whelk	17.6	25
Fishes	12.7	18
Debris	3.5	5
Other[A]	16.9	24

[A] Sand, mud, sea grasses, fluid, snails, shells, jellyfish (1), urchin

Table 10. Percent occurrence of crabs identified from digestive tract contents of sea turtles (n=102).

Prey Group	Percent Occurrence	N
Lady crabs	39.2	40
Hermit crab	10.8	11
Rock crab	5.9	6
Blue crab	12.7	13
Spider crab	9.8	10
Calico crab	2.9	3
Unidentified	16.7	17
Stone crab	2.0	2

A summary of the gut content analysis by sea turtle species is given in Figure 12. Loggerheads fed on a variety of prey items, including horseshoe crabs, whelk, crabs and fish, with horseshoe crabs and lady crabs occurring most frequently during the 13 year period. Kemp's ridleys seemed to feed exclusively on several species of crabs, while only fluids were found in the stomachs of leatherbacks (included in the other category), presumably the remnants of digested jellyfish. Seagrasses were documented in the single green sea turtle that stranded in Maryland waters in 1999. As mentioned above anthropogenic debris, consisting of mostly fish hooks and hook, line and sinkers, was only found in loggerhead digestive tracts. Since fish were not found in the digestive tracts of any other species of stranded turtles, this could reflect a preference for fish that are opportunistically available for consumption (e.g., caught on a fishing hook), which may lead to a higher incidence of interactions with fishing gear.

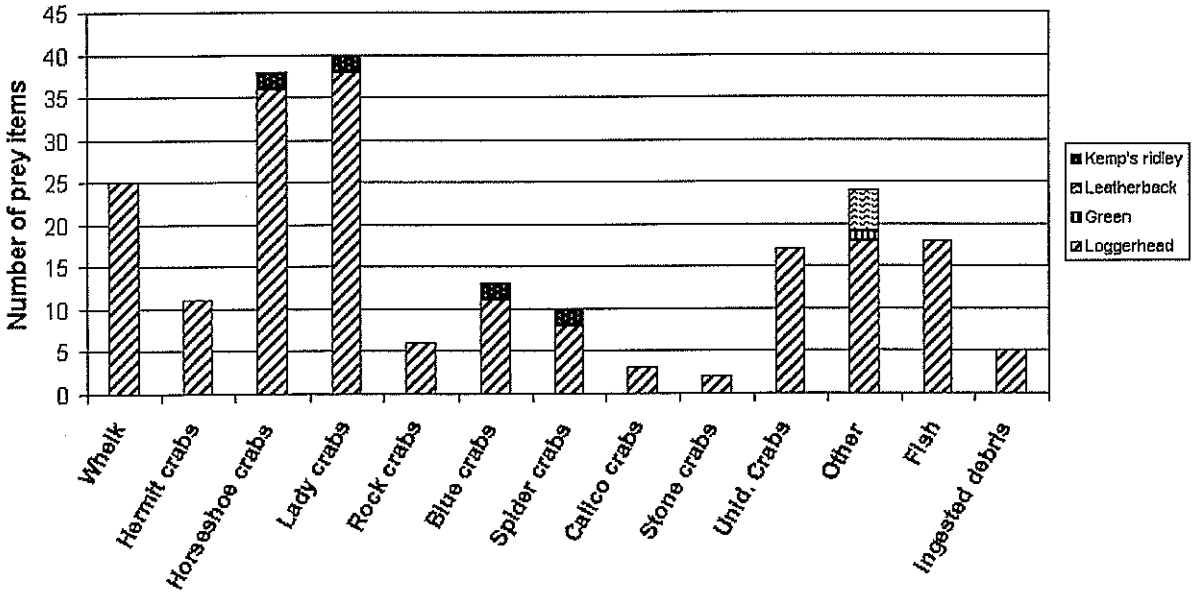

Figure 12. Frequency of occurrence of prey items in the gut samples of 4 species of sea turtles in Maryland waters from 1991 to 2003.

Human Interaction

The probable cause of death was undetermined in approximately 77% (n=237) of all sea turtles examined between 1991 and 2003. In Maryland, stranded sea turtles have been observed with a missing head or flippers, ingested fishing gear (e.g., hook and line) in the esophagus, stomach, or intestines, propeller wounds, and monofilament line or rope entangled around the flippers. Overall, anthropogenic impacts were documented as the probable cause of death in 23% (n=71) of the total number of stranded sea turtles. Boat related injuries from propeller impact or collision were identified as the probable cause of death in approximately 14.6% (n=45) of sea turtles strandings from 1991 to 2003. It is important to note, however, that it can be difficult to distinguish between pre- and post-mortem injuries when an animal is in a state of moderate to advanced decomposition. Therefore, it is possible that these numbers slightly overestimate the number of deaths attributed to boat related injuries. Approximately 7.8% (n=24) of sea turtle strandings were believed to be the result of fisheries interactions (including ingested gear). One

loggerhead died as the result of dredging activity and another from plastic ingestion. However, the moderate to advanced state of decomposition of most sea turtle carcasses can make evidence of human difficult to assess. Therefore, these numbers are at best estimations of human related mortality in Maryland. Observed sources of mortality near stranding sites were not consistently documented throughout the 13 year period and tended to only be noted when fisheries interaction was suspected as the cause of death. Scattered throughout the database are observations of potential sources mortality, including gill net markers, fishing vessels, and whelk pot buoys.

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